

**GAO**

United States General Accounting Office

Report to the Honorable Richard G.  
Lugar, U.S. Senate

September 1999

# NUCLEAR NONPROLIFERATION

## Status of Transparency Measures for U.S. Purchase of Russian Highly Enriched Uranium



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Resources, Community, and  
Economic Development Division

B-283458

September 22, 1999

The Honorable Richard G. Lugar  
United States Senate

Dear Senator Lugar:

After the breakup of the Soviet Union in the early 1990s, there was great concern that weapons-grade material from retired Russian nuclear weapons, such as highly enriched uranium and plutonium, could be stolen or reused in nuclear weapons if not disposed of or properly protected. In the case of highly enriched uranium, one solution was to dilute this nuclear material into low enriched uranium so that it could be made into fuel for commercial nuclear power reactors. In February 1993, the United States agreed to purchase from Russia 500 metric tons of highly enriched uranium extracted from dismantled Russian nuclear weapons over a 20-year period.<sup>1</sup> Russia agreed to dilute, or blend-down, the material into low enriched uranium before shipping it to the United States. From June 1995 through December 31, 1998, 1,487 metric tons of low enriched uranium, derived from 51 metric tons of highly enriched uranium, was delivered to the United States. USEC implements the commercial contract under the agreement and pays Russia for the deliveries of low enriched uranium.<sup>2</sup> Russia is expected to receive about \$12 billion from the agreement. As of April 1999, USEC had paid Russia almost \$940 million.

In accordance with the 1993 agreement, the United States and Russia negotiated a series of access and monitoring measures, known as transparency measures, at four nuclear material processing facilities that are located in closed Russian nuclear cities.<sup>3</sup> These transparency measures are designed to provide confidence that the arms control objectives of the agreement—reducing the number of Russian nuclear warheads—and the nonproliferation objectives—reducing Russia's inventory of weapons-grade highly enriched uranium—are met. More specifically, these measures are intended to provide confidence that the highly enriched uranium is extracted from dismantled Russian nuclear weapons and that the highly enriched uranium is then blended into low enriched uranium at

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<sup>1</sup>Formerly known as The Agreement Between the Government of the United States of America and the Government of the Russian Federation Concerning the Disposition of Highly Enriched Uranium Extracted From Nuclear Weapons (Feb. 18, 1993).

<sup>2</sup>Formerly a government-owned corporation, the United States Enrichment Corporation was privatized in July 1998 and is now known as USEC Inc., or USEC.

<sup>3</sup>Russia's 10 closed nuclear cities performed the most sensitive aspects of Russia's nuclear weapons production. Access to the closed cities is restricted, and they are geographically isolated.

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three Russian facilities. U.S. officials implement the measures through periodic monitoring visits to Russian facilities, where they observe the processes involved with converting highly enriched uranium into low enriched uranium, review nuclear material inventory records, and use equipment that measures the quality of the uranium to determine if it is weapons grade and could be used in a nuclear weapon.

As you requested, this report examines (1) the transparency measures that are in place, (2) whether these measures ensure that the nonproliferation objectives of the agreement are met, and (3) the proposals for additional transparency measures. This report is the unclassified version of a classified report that we issued to you on July 8, 1999. In addition to information on these three objectives, the classified report included information on whether the transparency measures ensure that the arms control objectives of the agreement—that the highly enriched uranium that is purchased by the United States is extracted from dismantled Russian nuclear weapons—are met.

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## Results in Brief

While most of the transparency measures have gradually been implemented at four Russian nuclear material processing facilities, several key measures have not yet been put into place. Moreover, under the agreement, U.S. officials lack access to Russian nuclear weapons dismantlement facilities and to the weapons dismantlement process. Some of the low enriched uranium delivered to the United States—about one-third—was shipped before the transparency measures had been implemented at each of the Russian facilities. According to the Departments of State and Energy, there was a deliberate decision by the U.S. government that U.S. interests would be served by allowing a portion of the highly enriched uranium to be blended into low enriched uranium and to be rapidly removed from Russia while the details of the transparency measures were being worked out. U.S. officials first visited a Russian facility in February 1996 to implement the initial set of transparency measures. In October 1996, Russian officials agreed to strengthen the measures in return for a \$100 million advance payment to be credited against their future deliveries of low enriched uranium. The most significant strengthened measures involve the (1) use of portable U.S.-manufactured equipment at various stages to confirm the presence or absence of weapons-grade highly enriched uranium and (2) installation of U.S. equipment that can continuously monitor whether the highly enriched uranium is blended into low enriched uranium. However, continuous-monitoring equipment has been installed at only one of the

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three Russian blending facilities after a 2-year delay and has not yet gone into routine operation. Russian officials have not agreed to a schedule for installing the equipment at the two other blending facilities.

Transparency measures provide U.S. officials with confidence that weapons-grade highly enriched uranium is being blended into low enriched uranium at the three Russian blending facilities. Nevertheless, U.S. officials will not be highly confident that all of the low enriched uranium purchased under the agreement is coming from weapons-grade highly enriched uranium until continuous-monitoring equipment is operating at the Russian blending facilities. Furthermore, according to the Department of Energy, U.S. officials rejected one cylinder of low enriched uranium that was shipped to the United States in 1997 for purchase under the agreement because it did not meet the agreement's requirements.

In March 1998, the Secretary of Energy proposed to the Russian Minister of Atomic Energy a number of additional transparency measures that included providing U.S. officials with greater access to the Russian nuclear-weapons-dismantlement process. However, Department of Energy officials told us that although one Russian facility has recently expressed an interest in a demonstration project, there has been no progress in reaching an agreement with Russia's Ministry of Atomic Energy on adopting these additional measures.

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## Background

Little official information is available on the sources, uses, and inventories of highly enriched uranium (HEU) in Russia, according to a May 1998 report by the Energy Information Administration (EIA).<sup>4</sup> EIA estimates, however, that Russia produced about 1,400 metric tons of weapons-grade HEU from 1950 through 1988, after which, Russia is believed to have stopped producing HEU for defense purposes.<sup>5</sup> The inventory of HEU remaining in Russia was estimated to be 1,270 metric tons at the end of 1994. EIA reported that not all HEU in Russia was used in nuclear weapons. For example, some HEU has been used as fuel for plutonium-production,

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<sup>4</sup>Commercial Nuclear Fuel From U.S. and Russian Surplus Defense Inventories: Materials, Policies, and Market Effects, EIA (May 1998).

<sup>5</sup>Uranium, in its natural form, comprises a mixture of several isotopes (forms of the same element with different atomic weights). Less than 1 percent of natural uranium is the isotope uranium 235 (U-235), the fissionable isotope used in nuclear weapons and reactors. Uranium that is enriched to a concentration of over 90 percent U-235 is highly enriched and is weapons-grade material. Uranium that is enriched to a concentration of from 3 to 5 percent U-235 is low enriched uranium and is commercial-reactor-grade material.

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research, and naval propulsion reactors.<sup>6</sup> EIA noted that most of the uranium used to produce HEU in the former Soviet Union reportedly came from fuel that was used in plutonium-production reactors.

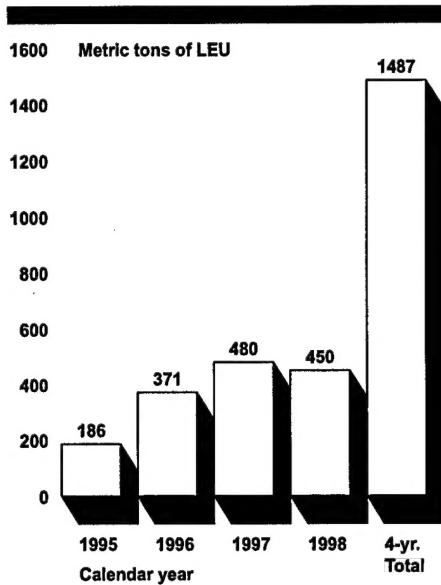
In January 1994, USEC signed a commercial contract with Techsnabexport to implement the February 1993 government-to-government agreement. Techsnabexport is a commercial arm of the Ministry of the Russian Federation for Atomic Energy (MINATOM) and is the Russian executive agent for the agreement. In November 1996, USEC and Techsnabexport signed an amendment to the commercial contract that established an agreement on the quantities and prices of low enriched uranium (LEU) for 5 years. The agreement provided for USEC to purchase LEU derived from 18 metric tons of HEU in 1997, 24 metric tons in 1998, and 30 metric tons annually from 1999 through 2001. According to USEC, from June 1995 through December 1998, USEC received 1,487 metric tons of LEU, as shown in figure 1.<sup>7</sup> From August 1998 through March 1999, Techsnabexport suspended the contracted deliveries of LEU to USEC, in part, because of Russia's dissatisfaction with progress in reaching an agreement on the price it would receive for the natural uranium that makes up a portion of the LEU. As a result, USEC received only 60 percent of the 1998 LEU shipments it had contracted for delivery. An agreement on the natural uranium was reached in March 1999, and a USEC representative stated that Techsnabexport delivered the last of the 1998 LEU shipments in June 1999.

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<sup>6</sup>Not all HEU is considered to be weapons-grade material. Any uranium enriched to 20 percent of U-235 or greater is considered to be highly enriched. Under the 1994 Transparency Protocol, the United States has the right to monitor only the concentration of U-235 in the uranium being processed.

<sup>7</sup>According to USEC, this quantity of LEU is derived from 51 metric tons of HEU, which the Department of Energy estimates is equivalent to the amount of HEU found in about 2,040 nuclear warheads.

**Figure 1: Annual Amounts of LEU Delivered to the United States From 1995 Through 1998**



Source: USEC.

Several U.S. and Russian government agencies are involved in the negotiation and implementation of the transparency measures. A Department of State official is designated as the Chief HEU Transparency Negotiator for the United States, and a Department of Energy (DOE) official is the Deputy Chief Negotiator. DOE's Office of Nonproliferation and National Security, contracting with most of DOE's national laboratories and several of its operations offices, implements U.S. transparency activities, such as staffing and organizing U.S. monitoring visits to the Russian facilities. DOE spent about \$44 million on HEU transparency activities from fiscal year 1994 through fiscal year 1998.<sup>8</sup> Lawrence Livermore National Laboratory spent about \$20 million, or about 45 percent of the total funds that DOE has provided, during this period. For the Russian Federation, MINATOM is responsible for negotiating and implementing the transparency measures.

The March 1994 Protocol on HEU Transparency Arrangements established the Transparency Review Committee as the formal bilateral mechanism

<sup>8</sup>DOE plans to spend an additional \$45 million for HEU transparency activities for fiscal year 1999 through fiscal year 2001.

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for U.S. (DOE and State Department) and Russian (MINATOM) officials to negotiate specific transparency measures at Russian and U.S. facilities and to discuss and resolve issues arising from the implementation of the measures. From 1994 through 1997, U.S. and Russian officials held six meetings of the Transparency Review Committee. An additional meeting of the executive members of the committee was held in February 1998.<sup>9</sup>

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## Transparency Measures Have Been Gradually Implemented at Russian Facilities

From February 1996 through May 1999, transparency measures were gradually implemented at four Russian nuclear material processing facilities. However, under the agreement, U.S. officials lack access to Russian nuclear weapons dismantlement facilities and to the process whereby nuclear weapons are dismantled. In October 1996, Russian officials agreed to strengthen the measures at the Russian facilities in return for a \$100 million advance payment to be credited against their future deliveries of LEU. Although Russian officials have allowed DOE to implement many of the transparency measures that were agreed to in 1996, there have been some delays and impediments in implementing them.

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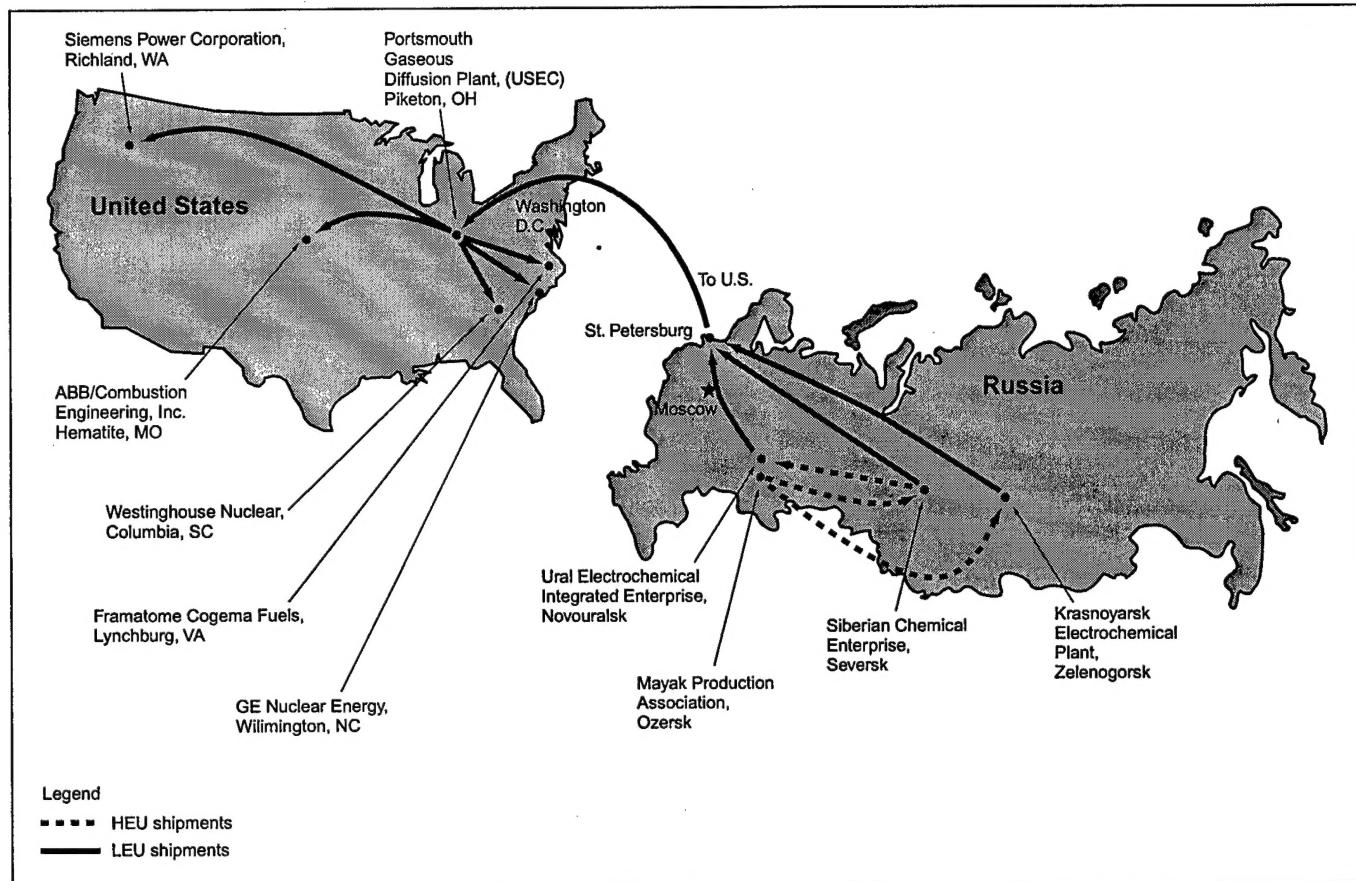
## Russian and U.S. Facilities That Process HEU and LEU

Currently, four Russian facilities process the HEU and six U.S. facilities process the LEU purchased under the agreement, as shown in figure 2. Under the agreement, the United States does not have access to the Russian weapons dismantlement facilities or to the weapons dismantlement process.<sup>10</sup> The Russian facilities are administered by MINATOM. Of the four Russian facilities, only three blend HEU into LEU. The Seversk facility is currently the only one that performs all of the processes related to the conversion and blending of HEU into LEU. (For a discussion of the fourth facility—Mayak—see pp. 10-11.) USEC operates one of the six U.S. facilities, the Portsmouth uranium enrichment facility, in Piketon, Ohio. USEC sends the LEU from the Portsmouth facility to five U.S. nuclear fuel fabricators that make nuclear reactor fuel for commercial nuclear power reactors. (See app. I for a description of the processes for converting and blending HEU into LEU at the Russian and U.S. facilities.)

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<sup>9</sup>In 1996, the United States also established a U.S. interagency committee, chaired by the National Security Council, to oversee the implementation of the U.S. national security and commercial objectives of the HEU purchase agreement. In May 1998, the committee was formalized by an executive order of the President as the Enrichment Oversight Committee and includes representatives from the Departments of State, Defense, and Energy; the intelligence community; and other federal agencies.

<sup>10</sup>According to DOE, there are four Russian nuclear weapons dismantlement facilities: Sverdlovsk-45, Zlatoust-36, Avangard, and Penza-19.

**Figure 2: Russian Federation and U.S. Facilities That Process HEU and LEU, as of June 1999**

Source: DOE.

### Transparency Measures at the Russian Facilities

Specific transparency measures, applicable to both Russian and U.S. facilities, are identified in 16 technical annexes to the March 1994 Protocol on HEU Transparency Arrangements that were signed from 1995 through 1998 as a result of six meetings of the Transparency Review Committee

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and one meeting of its executive members.<sup>11</sup> The date when each technical annex was signed generally determined when U.S. monitors could begin implementing the transparency measures at the Russian facilities.<sup>12</sup> As a result, about one-third of the shipments of LEU that were sent to USEC under the commercial contract, from 1995 through 1998, were not subject to transparency measures. (App. II provides a list of the 16 technical annexes that grant specific monitoring and access rights at the Russian and U.S. facilities. It also provides more information on the LEU shipments that were not subject to the transparency measures.)

Originally, two Russian facilities processed HEU—the Seversk and Ural facilities. In 1996, the Krasnoyarsk plant began to process HEU. According to DOE, starting in 1996, U.S. monitors were allowed to perform the following activities at these facilities:

- Observe the chemical processes whereby the HEU is transformed from metal chips—fragments of nuclear weapons components—into a gaseous form of HEU for blending purposes.<sup>13</sup>
- Visit the areas where HEU is blended into LEU.
- Apply tamper-indicating devices—U.S. tags and seals—to HEU and LEU containers to help monitors identify and track the movement of the material through the different processes or from one facility to another.
- Review and obtain copies of Russian nuclear material control and accounting documents to track the amount of HEU and LEU that is being processed.<sup>14</sup>
- At the Ural facility, from February 1996 through October 1998, U.S. monitors were able to take random samples of uranium, up to four times a year at the point where the uranium is blended (blendpoint), to measure the enrichment levels of the uranium that was being processed to determine whether HEU was being blended into LEU.

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<sup>11</sup>Russia also has the reciprocal right to implement transparency measures in the United States to determine whether the Russian LEU is fabricated into fuel for commercial nuclear power reactors and is not refabricated into HEU that could be used in U.S. nuclear weapons. From 1996 through 1998, MINATOM officials visited U.S. facilities seven times to implement these measures. In October 1998, representatives of the Portsmouth uranium enrichment facility told us that they would not produce weapons-grade HEU from the Russian LEU because they are prohibited by federal nuclear-licensing requirements from this activity. Moreover, the United States no longer requires new HEU for weapons production.

<sup>12</sup>In the case of the Ural facility, U.S. monitoring visits began after the technical annex for the facility had been initialed by the parties but before it was signed.

<sup>13</sup>During these chemical processes—oxidation and fluorination—the HEU metal chips are heated to convert them into an HEU oxide, and the HEU oxide is then converted into HEU hexafluoride, or UF<sub>6</sub>.

<sup>14</sup>When reviewing and obtaining documentation at the Russian facilities, U.S. monitors have access to some sensitive commercial information but do not have access to classified national security information.

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In October 1996, MINATOM agreed to a list of additional measures designed to strengthen transparency at the Russian facilities. In December 1996, MINATOM received an advance payment from USEC of \$100 million in exchange for agreeing to implement these additional measures. Some of these measures include the following:

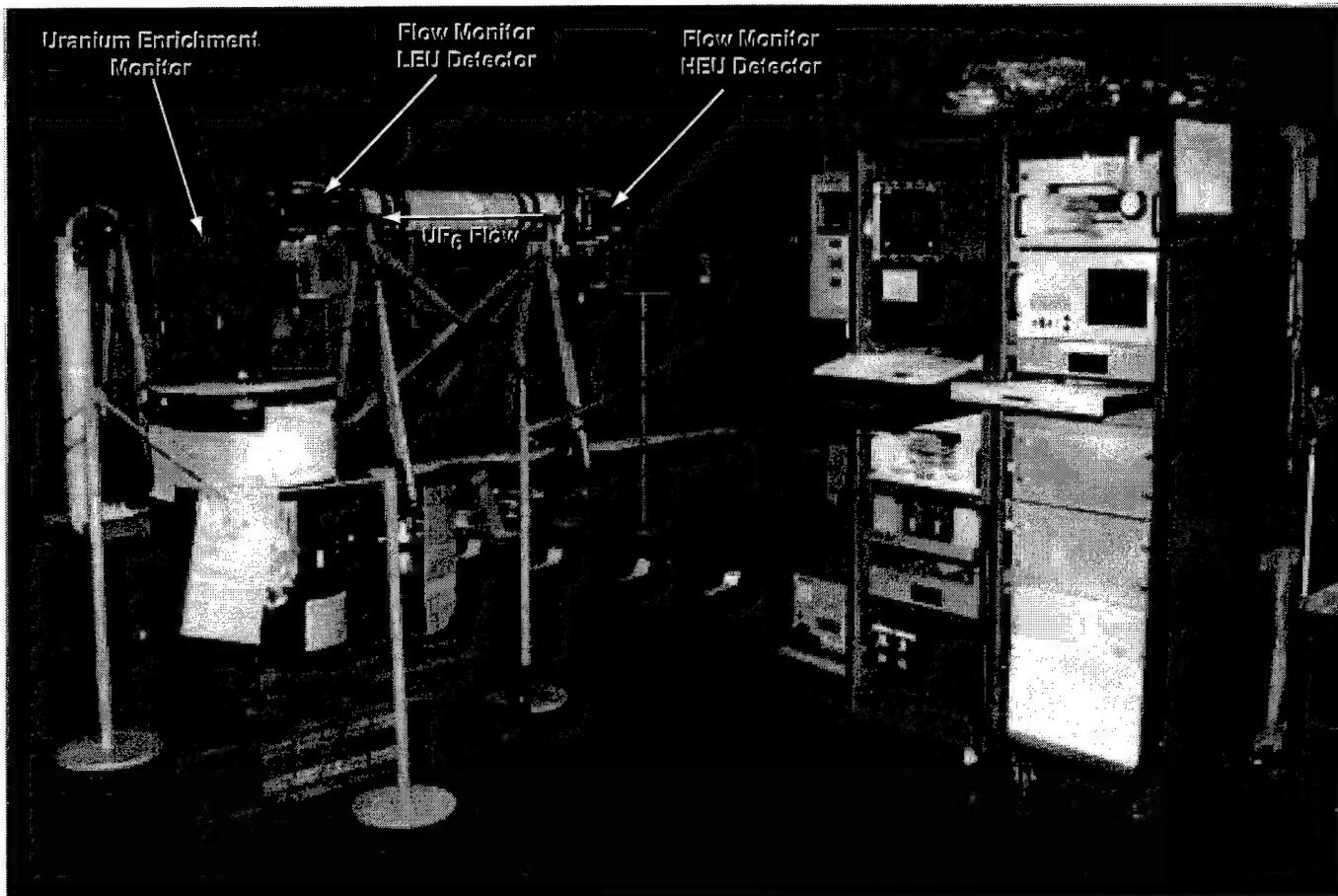
- Use of U.S.-manufactured portable equipment that measures the enrichment of the uranium and confirms the presence or absence of weapons-grade HEU at various stages of the conversion and blending processes. Since U.S. monitors are not certified to work in Russian facilities, Russian technicians, witnessed by U.S. monitors, operate the portable uranium detection equipment and record the results.
- Access to areas where HEU weapons components are received from the Russian dismantlement facilities and are stored in sealed containers.
- Ability to observe the process in which the weapons components are cut into metal chips.
- Access to the areas where the HEU oxide is chemically treated to remove certain impurities.<sup>15</sup>
- Installation of U.S. equipment that can continuously monitor the enrichment levels and material flow rate at the points where HEU is blended into LEU.<sup>16</sup> This equipment is shown in figure 3.

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<sup>15</sup>This chemical process is called purification.

<sup>16</sup>Oak Ridge and Los Alamos National Laboratories developed the continuous-monitoring equipment for installation at Russian blending facilities. According to equipment specifications, the equipment is designed to measure the flow rates of the uranium, tracking the amount of uranium that is being blended to within plus or minus 20 percent. The LEU blendstock that is used to blend HEU into LEU is uranium that has been enriched up to 1.5 percent U-235 by using depleted uranium containing less than 0.7 percent U-235.

Figure 3: U.S. Equipment That Continuously Monitors the Blending of HEU Into LEU



Source: DOE.

DOE started to implement most of the strengthened measures during monitoring trips to three of the Russian facilities beginning in 1997. In a February 1998 memo, DOE reported that Russian officials had implemented 95 percent of the strengthened transparency measures that were linked to USEC's December 1996 advance payment of \$100 million. The fourth facility, Mayak, started to process HEU under the agreement in 1997, but

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the transparency measures were not implemented there until after the technical annex had been signed for the facility in February 1998.

U.S. monitoring visits can occur up to six times each year at the Russian facilities, and each visit can last up to 5 days. U.S. monitors are required to notify MINATOM 30 working days in advance of their visits to the Russian facilities. Currently, DOE selects its monitors from a list of 100 persons from DOE, DOE's national laboratories and its contractors, and other U.S. agencies. The first monitoring trip took place in February 1996 at the Ural facility. According to DOE, from February 1996 through March 1999, U.S. monitors made 50 visits to the four Russian facilities, as shown in table 1.<sup>17</sup> In order to gain daily access to the HEU-blending process, in August 1996, DOE established a permanent monitoring office at the Ural facility in Novouralsk, Russia. Two to four U.S. monitors, who are rotated every 2 months, usually staff the permanent office and can visit the facility daily.<sup>18</sup> Because DOE now staffs a permanent monitoring office at the Ural facility, there has not been a need for periodic monitoring visits there since August 1996.

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<sup>17</sup>From fiscal year 1994 through fiscal year 1998, about 35 percent of the total \$44 million that DOE funded for implementing the transparency activities was spent on U.S. monitoring visits and on the establishment and maintenance of a permanent presence office in the Russian Federation.

<sup>18</sup>According to DOE, 55 U.S. monitors rotated through the permanent office at the Ural facility from August 1996 through March 1999.

**Table 1: U.S. Visits to Russian HEU-Processing Facilities From February 1996 Through March 1999**

| Facility                              | Familiarization visits <sup>a</sup> | Monitoring visits | Technical visits <sup>b</sup> | Total     |
|---------------------------------------|-------------------------------------|-------------------|-------------------------------|-----------|
| Ural Electrochemical Integrated Plant | 3                                   | 3                 | 4                             | 10        |
| Siberian Chemical Enterprise          | 2                                   | 15                | 0                             | 17        |
| Krasnoyarsk Electrochemical Plant     | 1                                   | 11                | 3                             | 15        |
| Mayak Production Association          | 2                                   | 6                 | 0                             | 8         |
| <b>Total</b>                          | <b>8</b>                            | <b>35</b>         | <b>7</b>                      | <b>50</b> |

<sup>a</sup>U.S. monitors visited the Russian facilities before transparency measures were in place to familiarize themselves with the facilities' operations.

<sup>b</sup>U.S. monitors can visit the Russian blending facilities to assist in the installation of U.S. continuous-monitoring equipment.

Source: DOE.

### Delays and Impediments to Implementing Some Measures at the Russian Facilities

Although Russian officials have allowed DOE to implement most of the strengthened transparency measures that were agreed to in 1996, there have been delays and impediments to implementing some of them. Despite these difficulties, State Department and DOE officials believe that the measures have given them unprecedented access to facilities in Russian closed cities. Since 1996, DOE has continued to negotiate for access to the process whereby HEU weapons components are cut into metal chips. Both Russian and U.S. officials consider information about the design of their weapons to be classified, including the shapes of their weapons components. Accordingly, DOE has suggested that weapons components could be shrouded during the metal-chipping process when U.S. monitors are present to allow them to witness the process without revealing classified information. DOE officials told us that the Mayak facility has recently expressed an interest in conducting a demonstration of shrouding weapons components during the metal-chipping process but that MINATOM has not yet approved this proposal.

Moreover, the installation of U.S. continuous-monitoring equipment at the Russian Ural facility was delayed for 2 years. The delay was due to a number of factors, including requirements by the Russian government to

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license and certify the equipment before it was installed and concerns by Russian officials about how data generated by the equipment would be used by the United States. In January and February 1999, DOE officials and national laboratory staff installed and tested the monitoring equipment at the Ural facility. During this test, U.S. officials found that the equipment could accurately detect the enrichment levels of the uranium but that the equipment needed some adjustments to properly measure the amount of LEU that was being processed. Before the equipment can go into routine operation at the facility, these technical problems must be fixed, and a revised technical annex and other agreements for the facility must also be approved and signed by the United States and the Russian Federation. According to a February 1999 cable from the U.S. Embassy in Moscow, DOE and MINATOM had not resolved their differences over how the United States will remove or use the data generated by the monitoring equipment and what steps both parties will take to resolve any discrepancies that may occur between the data generated by the equipment and the Russian facility's own documentation of its nuclear material.

DOE and Lawrence Livermore officials told us that they plan to install continuous-monitoring equipment at the second Russian blending facility at Krasnoyarsk by the end of September 1999. However, DOE is waiting to ship the equipment to Krasnoyarsk until the Department receives final approval from MINATOM to install and operate the equipment. According to DOE, an agreement has not yet been reached with MINATOM on the details for installing the equipment at Seversk, the third Russian blending facility. A DOE official told us that before the equipment can be installed at these two blending facilities, MINATOM would likely require that the technical annexes related to the transparency procedures for these facilities be revised and renegotiated. A MINATOM official told us in September 1998 that he considered the installation of the equipment at the Ural facility to be a pilot test and that there were no specific plans for installing the equipment at the other two facilities. DOE officials disagreed with MINATOM's statement because, in October 1996, Russian officials had granted the United States the right to install this equipment at the Ural, Krasnoyarsk, and any future Russian blending facilities. At the time of our review, this matter had not yet been resolved.

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## Confidence Exists That Weapons-Grade HEU Is Blended Into LEU

Transparency measures provide U.S. officials with confidence that weapons-grade HEU is being blended into LEU at the Russian blending facilities. Nevertheless, U.S. officials have stated that until continuous-monitoring equipment is installed at the three Russian blending facilities, they will not be highly confident that all of the LEU that the United States is purchasing is coming from blended HEU. Furthermore, in response to the concerns we raised, DOE improved its procedures for collecting information on the LEU cylinders shipped under the agreement through its arrangements with USEC.

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## U.S. Officials Have Confidence That LEU Is Coming From Weapons-Grade HEU

DOE and Lawrence Livermore officials told us that they have confidence that weapons-grade HEU is being blended into LEU at the Russian blending facilities.<sup>19</sup> DOE and Lawrence Livermore officials told us that until continuous-monitoring equipment is installed at the three Russian blending facilities, they will not be highly confident that blending is occurring and that all of the LEU that the United States is purchasing is coming from blended HEU. For example, although the continuous-monitoring equipment has been installed at the Ural facility, this facility is scheduled to blend only 12 metric tons of the total 30 metric tons of HEU to be delivered as LEU for 1999.

There are several ways in which U.S. monitors can gain confidence that weapons-grade HEU is being converted and blended into LEU at the Russian facilities. U.S. monitors are allowed to use U.S. portable equipment, apply identifying U.S. tags and seals to containers and equipment that indicate tampering, and obtain Russian nuclear material inventory documentation on the HEU and LEU in containers at each step of the conversion and blending processes. According to Lawrence Livermore officials, the equipment allows U.S. monitors to determine, with high confidence, that the HEU that is being processed when the U.S. monitors are present is weapons-grade material. Since 1997, six times a year, U.S. monitors have been able to visit areas at the Mayak and Seversk facilities where sealed containers that were used to ship HEU weapons components are stored. They can also observe the HEU after it has been cut into metal chips. At two blending facilities—Seversk and Krasnoyarsk—U.S. monitors can observe and measure the enrichment of the HEU in containers six times a year as they are fed into the blendpoint.

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<sup>19</sup>Our July 8, 1999, classified report discusses U.S. officials' confidence that the HEU that has been purchased under the agreement is coming from Russian dismantled nuclear weapons.

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At the Ural facility, permanent monitors have daily access to the blending area, where they can apply U.S. tags and seals to HEU in containers and to some equipment, and can obtain Russian documentation that shows the amounts of HEU and LEU that are being blended. From February 1996 through October 1998, U.S. monitors were able to randomly request that Russian technicians take samples of the HEU and LEU at the blendpoint. An analysis of the samples, which were limited to being taken four times a year, provided a snapshot of the enrichment levels of the HEU and LEU in the pipes at the time of sampling. As of October 1998, DOE reported that a total of 11 samples had been taken and analyzed by Russian technicians under observation by U.S. monitors. The analysis showed that weapons-grade HEU was being blended.<sup>20</sup> When put into routine operation, the continuous-monitoring equipment that was recently installed at the Ural facility will provide U.S. monitors with a continuous record of whether blending is occurring. As a result, random samples will no longer be taken there.

DOE and Lawrence Livermore officials have stated that because the access granted to U.S. monitors is limited at each of the Russian facilities, they are unable to track the HEU through the entire process as it is converted and blended into LEU. Additionally, State Department and Lawrence Livermore officials told us that the continuous-monitoring equipment does not provide U.S. monitors with information on whether the HEU that is being blended is of weapons origin.

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**One Cylinder of LEU Was Rejected Under the Agreement**

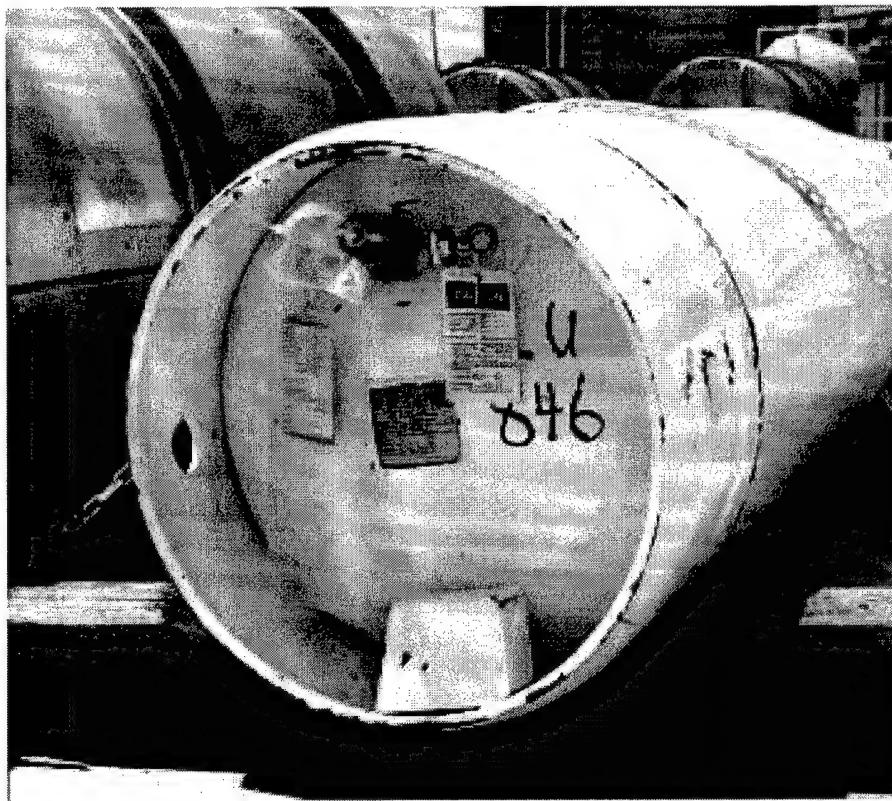
In 1997, U.S. monitors discovered that one cylinder of LEU that was shipped to the United States did not meet the requirements of the agreement. In an October 27, 1997, letter, the Department of State informed MINATOM that it would not accept the cylinder under the HEU purchase agreement. According to an April 1998 unverified press account, U.S. officials were uncertain of whether the cylinder contained LEU that came from HEU from nuclear warheads. However, according to USEC officials, on February 1, 1999, USEC paid Russia's Techsnabexport for the cylinder under a separate commercial agreement. Figure 4 shows the disputed cylinder.

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<sup>20</sup>DOE paid the Russian Ural facility \$124,391 to perform all 11 of these analyses.

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**Figure 4: Disputed Cylinder of LEU  
Rejected Under HEU Purchase  
Agreement**



Source: Portsmouth Uranium Enrichment Facility.

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### USEC Documentation and Reporting

Until recently, U.S. monitors did not always obtain documentation on the contents of all of the LEU cylinders shipped under the agreement in a timely manner. A USEC representative told us that USEC had not been required to regularly share cylinder documentation data with DOE but, as a matter of practice, had shared this information with DOE upon request. During our review, we raised concerns with DOE officials about whether they should formalize their data-sharing arrangement with USEC and receive USEC documentation more routinely. In response to our concerns, in March 1999, DOE officials formally requested that USEC send them the results of USEC's and the Russian facilities' documentation on the contents of the LEU cylinders on a monthly basis. DOE officials stated that by regularly receiving this information from USEC, they could be more

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confident that the LEU obtained under the agreement is consistent with the process of blending HEU. USEC provided DOE with the first of these monthly reports on May 7, 1999.

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## U.S. Officials Are Seeking Additional Transparency Measures

In March 1998, the Secretary of Energy proposed a number of additional transparency measures to the Russian Minister of Atomic Energy. In September 1998, we asked MINATOM officials if they planned to grant any broader access to U.S. transparency monitors. MINATOM officials responded that broader access for U.S. monitors, such as access to the Russian weapons dismantlement process, would have to be negotiated in the context of other arms control agreements.<sup>21</sup> DOE officials also acknowledged that it could be difficult to achieve broader access for U.S. monitors in the absence of an arms control agreement whereby both the United States and Russia could verify reductions in nuclear weapons and classified information about nuclear weapons could be exchanged.

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## Agency Comments

We met with officials from the Departments of State and Energy to receive the Departments' comments on a draft of this report. Specifically, we obtained comments from the Director, Office of Policy and Regional Affairs for Russia and the New Independent States, Department of State, and the Deputy Director, Office of Arms Control and Nonproliferation, Department of Energy. The Departments of State and Energy stated that the report's findings were fair and balanced.

The Departments of State and Energy also provided technical comments that were incorporated into the report as appropriate.

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## Scope and Methodology

To examine the status of the implementation of the transparency measures, we reviewed the February 1993 government-to-government HEU purchase agreement, the September 1993 Memorandum of Understanding Relating to Transparency and Additional Arrangements, the March 1994 Protocol on HEU Transparency Arrangements, and 16 technical annexes to the 1994 Protocol, signed from 1995 through 1998, that grant specific monitoring and access rights at the U.S. and Russian facilities. We also

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<sup>21</sup>In our report entitled *Weapons of Mass Destruction: Effort to Reduce Russian Arsenals May Cost More, Achieve Less Than Planned* (GAO/NSIAD-99-76, Apr. 13, 1999), we discuss the status of a facility that is being constructed with U.S. funds at the Mayak nuclear complex to store plutonium removed from dismantled Russian nuclear weapons. The report found that Russian negotiators had not yet agreed to U.S. proposals aimed at confirming that the plutonium to be stored at Mayak would originate solely from dismantled nuclear weapons and would support Russia's dismantlement of nuclear weapons.

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reviewed the records of five of the six meetings of the bilateral Transparency Review Committee, which occurred from September 1994 through November 1997. According to DOE officials, no records were issued for the fifth meeting of the committee in December 1996 and the meeting of the executive members of the committee in February 1998 because the signed transparency annexes served as the records of these meetings. We obtained and reviewed unclassified and classified reporting cables from the U.S. Department of State and the U.S. Embassy in Moscow, Russia, covering the period from 1992 through 1999. DOE provided us with trip reports covering the period from 1994 through 1999, which documented U.S. monitors' visits to the Russian facilities to implement the transparency measures. To identify DOE's funding of transparency activities from fiscal year 1994 through fiscal year 2001, we also obtained budgetary and expenditure data from DOE. We reviewed relevant technical and energy trade publications covering the period from 1991 through June 1999.

In Washington, D.C., we met with officials from the Department of State's Office of Policy and Regional Affairs for Russia and the New Independent States; DOE's Offices of the Undersecretary, Nuclear Energy, Science and Technology, Arms Control and Nonproliferation, and International Nuclear Safety and Cooperation; DOE contractors from Lawrence Livermore National Laboratory; and EIA. Several U.S. officials whom we met with had served as U.S. monitors who staffed DOE's permanent office at the Russian Ural facility or regularly participated in the monitoring visits to the Russian facilities. We also met with officials from the Department of Defense and several agencies that represent the U.S. intelligence community.

We visited Moscow, Russia, in September 1998 to meet with various U.S. officials from the U.S. Embassy and with Russian officials from MINATOM and one of its commercial subsidiaries—Techsnabexport.

To discuss the commercial aspects of the purchase agreement that had an impact on transparency measures, we also met with and gathered information from representatives of USEC—the U.S. executor of the agreement—in Bethesda, Maryland. We met with the President of Edlow International Company, in Washington, D.C., who was responsible for managing all of the shipments of the LEU from St. Petersburg, Russia, to the United States. We visited the two uranium enrichment facilities operated by USEC—the Portsmouth facility in Piketon, Ohio, and the Paducah, Kentucky, facility. We also met with representatives of one of the

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five U.S. fuel fabricators—GE Nuclear Fuel, in Wilmington, North Carolina.

We conducted our review from August 1998 through June 1999 in accordance with generally accepted government auditing standards.

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We are sending copies of this report to Senator Jesse A. Helms, Chairman, and Senator Joseph R. Biden, Ranking Minority Member, Senate Committee on Foreign Relations; Representative Benjamin A. Gilman, Chairman, and Representative Sam Gejdenson, Ranking Minority Member, House Committee on International Relations; and other appropriate committees.

We are also sending copies of this report to the Honorable Madeleine K. Albright, the Secretary of State; the Honorable Bill Richardson, the Secretary of Energy; the Honorable William S. Cohen, the Secretary of Defense; and other interested parties. If you have any questions or need additional information, please contact me or Gene Aloise, Assistant Director, on (202) 512-3841. Other major contributors to this report were Sarah Veale, Victor Sgobba, and Duane Fitzgerald, Ph.D.

Sincerely yours,



(Ms.) Gary L. Jones  
Associate Director, Energy,  
Resources, and Science Issues

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**Contents**

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**Abbreviations**

|         |  |
|---------|--|
| DOE     | Department of Energy                                 |
| EIA     | Energy Information Administration                    |
| GAO     | General Accounting Office                            |
| HEU     | highly enriched uranium                              |
| LEU     | low enriched uranium                                 |
| MINATOM | Ministry of the Russian Federation for Atomic Energy |

# Processes for Converting and Blending Highly Enriched Uranium Into Low Enriched Uranium at Russian and U.S. Facilities

Four Russian facilities convert and blend highly enriched uranium (HEU) into low enriched uranium (LEU) through the following processes:

- Seversk and Mayak receive HEU weapons components from the Russian weapons dismantlement facilities, cut the components into metal chips, and heat the HEU metal chips to convert them into oxide.
- Seversk and Mayak chemically treat the HEU oxide to remove certain impurities.<sup>22</sup> Seversk and Krasnoyarsk combine the purified HEU oxide with fluorine to produce HEU hexafluoride, also known as UF<sub>6</sub>.
- Seversk, Krasnoyarsk, and Ural blend the HEU into LEU. During the blending process, the HEU is blended with uranium that is enriched up to a level of 1.5-percent U-235—called blendstock—to produce LEU.
- Seversk, Krasnoyarsk, and Ural load the LEU into cylinders that contain about 1.5 metric tons of LEU each. The cylinders are transported by rail to St. Petersburg, Russia, and from there, they are shipped to the United States.

Once the LEU arrives in the United States, six U.S. facilities perform the following processes:

- The Portsmouth uranium enrichment facility may further change the enrichment of the LEU to meet USEC customers' commercial specifications or the cylinders may be sent as received to the five U.S. nuclear fuel fabricators.
- The five U.S. nuclear fuel fabricators convert the LEU into reactor fuel and sell it to electric utilities in the United States and other countries.

<sup>22</sup>Some of the initial shipments of LEU under the agreement contained traces of plutonium and other impurities. In order to meet the U.S. uranium industry's standards for product purity, Russia began to process the HEU to remove any impurities starting in 1996 at the Seversk facility.

# Technical Annexes Establish Implementation of Transparency Measures

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Sixteen technical annexes to the 1994 Transparency Protocol implement access and monitoring procedures at the U.S. and Russian facilities subject to the 1993 government-to-government HEU purchase agreement. From 1995 through 1998, the United States and the Russian Federation signed these annexes, some of which were revised as new Russian facilities or as new processes were added. As a result, some of the shipments sent to the United States under the commercial agreement from the Russian facilities were not subject to the transparency measures. The technical annexes governing the U.S. monitoring of Russian facilities will continue to be revised if the HEU conversion and blending activities of the Russian facilities change or when new transparency activities are implemented, such as installing equipment that continuously monitors whether HEU is being blended into LEU at the three Russian blending facilities.

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## Technical Annexes Implement Transparency Measures

From 1995 through 1998, U.S. and Russian negotiators signed 16 technical annexes to the 1994 Transparency Protocol that established specific access and monitoring rights at U.S. and Russian facilities. When two additional Russian facilities started to process HEU under the agreement and some of the facilities added new processes, technical annexes had to be negotiated for each of these facilities, and some annexes had to be revised and renegotiated to accommodate the new processes, as demonstrated by figure II.1.

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**Appendix II**  
**Technical Annexes Establish**  
**Implementation of Transparency Measures**

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**Figure II.1: Titles of Transparency Annexes to 1994 HEU Transparency Protocol, by Major Category**

**Administration**

**Annex 1**  
**Transparency**  
**Review**  
**Committee,**  
**7/28/95**

**Annex 2**  
**Notification of**  
**Visits & Related**  
**Arrangements,**  
**7/28/95**

**Annex 10**  
**Financial**  
**Arrangements,**  
**4/4/96**

**Annex 11**  
**Reexport of**  
**Russian LEU,**  
**4/3/96**

**Annex 14**  
**Exchange of**  
**HEU Material**  
**Reports,**  
**4/3/96**

**Processes**

**Annex 7**  
**Analytical**  
**Methods for**  
**U-235,**  
**4/3/96**

**Annex 8**  
**Tags and**  
**Sseals,**  
**11/22/95**  
**revised 4/4/96**

**Annex 9**  
**Technological**  
**Process**  
**Descriptions,**  
**4/4/96**

**Annex 12**  
**Equipment,**  
**4/4/96, revised**  
**12/18/96**

**Annex 13**  
**Radioactive**  
**Standards,**  
**4/4/96**

**Procedures for U.S. Monitoring of Russian Facilities**

**Annex 3<sup>a</sup>**  
**Ural,**  
**4/2/96,**  
**revised 12/20/96**

**Annex 5**  
**Seversk,**  
**4/2/96,**  
**revised 12/18/96**  
**& 2/11/98**

**Annex 15**  
**Krasnoyarsk,**  
**12/20/96**  
**amended 2/11/98**

**Annex 16**  
**Mayak,**  
**2/11/98**

**Procedures for Russian Monitoring of U.S. Facilities**

**Annex 4**  
**Portsmouth,**  
**4/2/96,**  
**revised 12/20/96**

**Annex 6**  
**Fuel**  
**Fabricators,**  
**4/2/96,**  
**revised 12/20/96**

**Some Shipments Were**  
**Not Subject to**  
**Transparency**

Some LEU shipments were sent to the United States under the 1994 commercial contract between USEC and Techsnabexport before the transparency measures had been implemented at each of the Russian blending facilities. According to the Departments of State and Energy,

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**Appendix II**  
**Technical Annexes Establish**  
**Implementation of Transparency Measures**

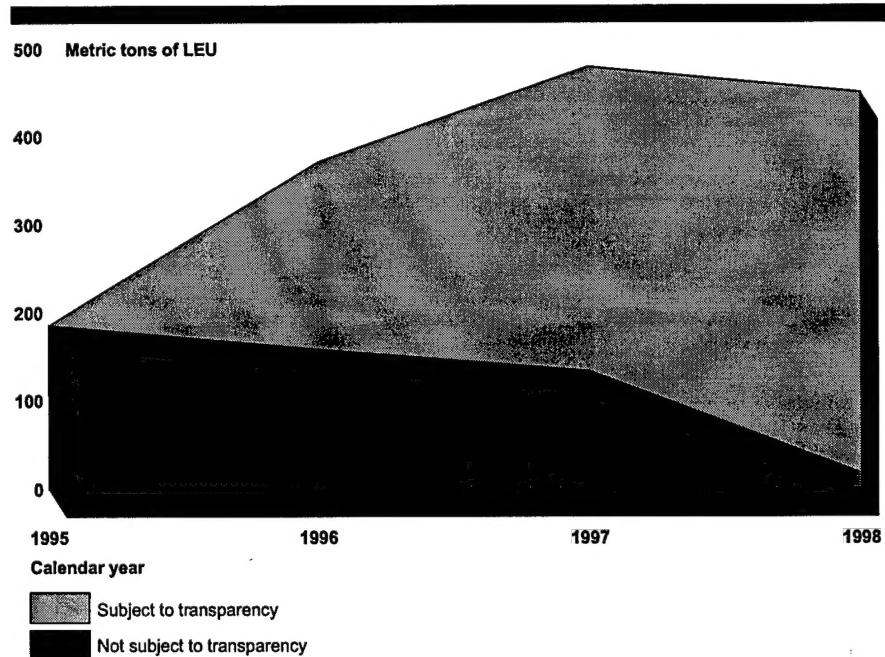
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there was a deliberate U.S. government decision that U.S. interests would be served by allowing a portion of the HEU to be blended into LEU and to be rapidly removed from Russia while the details of the transparency measures were being worked out. In addition, by allowing the shipments to begin before the transparency measures were in place, Russia could begin receiving much needed financial revenue from the HEU agreement.

From 1995, when the first LEU deliveries started, through 1998, about one-third—496 metric tons of the total 1,487 metric tons—of the LEU sent to the United States was not subject to transparency measures, as shown in figure II.2. The amount of LEU that was not subject to transparency measures was equivalent to about 17 metric tons of HEU. For example, officials from Lawrence Livermore National Laboratory told us that because the technical annex was not signed for the Ural facility until 1996, the United States was not permitted to monitor any of the 1995 LEU shipments sent to the United States under the agreement. All of the 1995 LEU shipments came from that facility.

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**Figure II.2: Some LEU Shipments Were Not Subject to Transparency Measures**



Source: Department of Energy.

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